# PATENT ABSTRACTS OF JAPAN

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(54) **SURFACE COATED END MILL**

(57)Abstract:
PROBLEM TO BE SOLVED: To improve the adhesion and wear resistance of a film by regulating the diffraction intensity of the plane in the X-ray diffraction of a coating later to a specific value, in an end mill coated with combined nitride, carbo-nitride, carbide of Ti and Al.
SOLUTION: When the diffraction intensity of (111) plane and the diffraction intensity of (222) plane are represented by I(111) and I(222), respectively, the value of I(222)/I(111) of surface coating is regulated to ≤2. A nitride layer or carbo-nitride layer of Ti, having 0.05-5μm film thickness, is formed between the base material of an end mill and a coating layer. It is preferable that a monolayer of one kind among the carbo-nitride and nitrogen carbonate of Ti, the combined nitrogen oxide, nitrogen carbonate, carbon oxide, and oxide of Ti and Al, and Al oxide or a multilayer of two or more kinds among them is further formed by coating on a layer of combined nitride, carbo-nitride, carbide of Ti and Al. Moreover, it is preferable that a part of Ti is replaced by one or more elements among Zr, Hf, T, Si, W and Cr, within the range of 0.05-60 atomic % based on Ti.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the covering end mill which is rich in abrasion resistance and a peeling resistance.
[0002]
[Description of the Prior Art] There are much reports which checked the aluminum addition effect to a TiN coat so that each official report of JP,4-53642,B and JP,5-67705,B may see Ti and aluminum in ancient times about the hard covering member which carries out a principal component. However, in these invention, the oxidation-resistant improvement in the coat by aluminum addition and an improvement of coat physical properties do not pass to have accepted, but it has come to obtain the adhesion of the coat fully satisfied, and abrasion resistance in a covering end mill. especially -- recently -- metal mold -- the tool life which the inclination processed in processing after metal mold's heat-treating is strong, it is easy to generate exfoliation of a coat during cutting, and a tool life is determined by exfoliation in the end mill which makes conventional Ti and conventional aluminum a principal component when processing the high degree-of-hardness steel after heat treatment, and abrasion resistance is also inadequate, and is satisfied has come to be acquired
[0003]
[Problem(s) to be Solved by the Invention] this invention person etc. came to find out the following facts, as a result of repeating that such a trouble should be solved ] research wholeheartedly in cutting evaluation of the high degree-of-hardness steel exceeding Rockwell hardness 50 (C scale weighting) that the adhesion of a coat and abrasion resistance should be improved.
[0004]
[Means for Solving the Problem] The 1st knowledge which resulted in this invention is in the point which found out that the optimal coat design should change with differences of a cutting mechanism in each, although various tools, such as a slow away insertion, an end mill, and a drill, are used when processing metal mold. In end-mill cutting of the high degree-of-hardness steel exceeding especially HRC50, it is the feature that cutting stress is very high, are easy to generate exfoliation of a coat, a cutting temperature amounts to 500 degrees C - 800 degrees C or more further, and the elevated-temperature physical properties of a coat determine a tool life. Therefore, in cutting by the end mill of high degree-of-hardness material, making the adhesion of a coat and elevated-temperature physical properties improve based on these knowledge will improve a tool life sharply.
[0005]
[Function] The 2nd knowledge is in the point which found out that the orientation of the field in the X diffraction (111) of a coat governed the adhesion on the appearance of the coat in end-mill cutting, and elevated-temperature physical properties to the 1st knowledge. That is, the orientation of a field (111) followed on becoming strong, the diameter of a columnar grain of a coat became small, and the conclusion that it was possible to raise the hardness in a room temperature was obtained. In the case of the end mill, in cutting of 50 or more-HRC high degree-of-hardness steel, the hardness of a coat found out especially that exfoliation of a coat could not generate a stiff easily. That is, in the tool which has a comparatively sharp edge like an end mill, the shearing stress generated especially in high degree-of-hardness steel there when the edge of a blade costs several 10-micrometer minute slitting is high, for example, when coating is not given, with a sharp edge, thickness is thin and the base itself cannot stand this high shearing stress primarily. That is, it is that it is very important to protect a base by the stiff "Calah." Therefore, even if it protects a base by the soft coat, high shearing stress cannot be stood. The intensity of the sharp edge itself increases only after protecting a base in stiff Calah. When a base is protected by the soft coat, a minute chipping occurs with the plastic deformation of a base, without standing high shearing stress locally, and cutting stress increases by this case further, as a result exfoliation of a coat and a big chipping are made generated. Moreover, the room temperature hardness of hardness at high temperature of a coat is hard to a stiff and 500-800 degrees C, and a result which the hardness of a coat is saved and brings about a long tool life also at an elevated temperature is brought to end-mill cutting.
[0006] The 3rd knowledge which resulted in this invention is the point which found out that it was possible to raise the adhesion of a coat further by using the nitride of Ti, and a charcoal nitride as an interlayer between the nitrides of Ti and aluminum, the charcoal nitrides, carbide coats, and bases to which orientation of the above-mentioned field (111) is carried out more strongly. When carrying out the vacuum evaporationo of the coat which generally contains aluminum by the physical vapor deposition, especially the arc ion plating method, since the melting point of aluminum is low, the big and rough particle which was rich in aluminum component disperses from a target, and is in the inclination which worsens field granularity of a coat. It is in the

improvement in adhesion that avoiding such reduction in the stage in early stages of [ coating ] a base, and forming a precise coat prepares the interlayer who consists of the nitride which makes a principal component Ti which is effective to the improvement in adhesion and does not contain aluminum, and a charcoal nitride better for taste, and it becomes resulting. The coat containing Ti and aluminum grows epitaxially to an interlayer, and adhesion is made to improve further by using the interlayer who did orientation to the field similarly (111) to the coat containing Ti and aluminum which carried out orientation to the field especially (111).

[0007] By suppressing generating of heat further at the time of the above-mentioned cutting, the 4th knowledge which resulted in this invention is in the point which found out that it was possible to raise a tool life further. Generally the compound nitride of Ti and aluminum, a charcoal nitride, and carbide had coefficient of friction as high as 0.40-0.45 to steel, according to research of this invention person from whom the edge of a blade tends to become an elevated temperature at the time of cutting, by making these coats contain oxygen, reduction of coefficient of friction was able to be attained and improvement in the further tool life by reduction of cutting heat was able to be checked by using for an outermost layer of drum. Furthermore, reduction of coefficient of friction can be further measured in order of the charcoal nitride of Ti, a carbonic acid nitride, and the oxide of aluminum, and it came to accept improvement in much more tool life by using these coats for an outermost layer of drum. Furthermore, the oxide of aluminum has high adhesion, when membranes are formed by plasma CVD. Furthermore, by carrying out the lap of the front face of the coat of an end-mill slot mechanically, and setting surface roughness to 1 micrometer or less, reduction of coefficient of friction is still more possible, and it is possible to raise a tool life.

[0008] The 5th knowledge which resulted in this invention is in the point which enabled oxidation-resistant improvement by transposing one sort or two sorts or more of components to the compound nitride of Ti and aluminum, a charcoal nitride, and carbide in 0.05at% to 60at(s)% to Ti among Zr, Hf, Y, Si, W, and Cr. In cutting of an end mill, although it is not a slow more nearly away insertion, the oxidation resistance of a coat is also important. While it is possible for oxidization of the grain boundary to be suppressed by addition of these components, and to suppress the oxidation rate of a coat, it is able for the oxide layer formed on a coat front face during cutting to serve as more precise structure, to suppress diffusion inside [ of oxygen ] a coat, and to make the oxidation rate of a coat very late. About these reasons, it is under research further.

[0009] Next, the reason for having carried out numerical limitation is explained. (200) when diffraction intensity of the diffraction on-the-strength I (200) (111) side of a field is set to I (111), the reason for having made I (200)/I (111) or less into 2.0 has a big and rough particle size of a columnar-crystal layer, when the orientation of a field (200) becomes strong and this value exceeds 2.0 -- turning -- the fall of room temperature hardness, and an elevated temperature -- in order to bring about an advanced fall, it carried out to 2.0 or less

[0010] The thickness of a nitride and a charcoal nitride layer was ineffective to the adhesion improvement in it being less than 0.05 micrometers, and it also set to 0.05 micrometers or more 5.0 micrometers or less Ti used as an interlayer in order to spoil the abrasion resistance of the whole coat, if 5.0 micrometers is exceeded. By below 0.05 atom %, components, such as Y added for oxidation-resistant improvement, were made below into 60 atom % more than 0.05 atom % in order to degrade abrasion resistance, if the effect over oxidation resistance replaces Ti exceeding 60 atom % few.

[0011]

[Example]

In the conditions shown in Table 1 using an example 1 small arc ion plating system, it coated so that it might become the thickness of 3 micrometers about the compound nitride of Ti and aluminum, and a charcoal nitride.

[0012]

[Table 1]

| 試料番号 | | コーティング条件 バイアス電圧 V | コーティング条件 真空度 mbar | 皮膜 | I(200)／I(111) | 切削長(m) |
|---|---|---|---|---|---|---|
| 本発明例 | 1 | 200 | $3.0\times10^{-3}$ | (Ti$_{0.6}$Al$_{0.4}$)N | 0.1 | 28m (正常摩耗 0.2mm) |
| | 2 | 150 | $2.0\times10^{-3}$ | 〃 | 1.8 | 23m 〃 |
| | 3 | 100 | $1.0\times10^{-3}$ | 〃 | 0.9 | 22m 〃 |
| | 4 | 100 | $2.0\times10^{-3}$ | 〃 | 2.0 | 18m 〃 |
| | 5 | 100 | $0.5\times10^{-3}$ | 〃 | 1.0 | 25m 〃 |
| 比較例 | 6 | 20 | $3.0\times10^{-3}$ | (Ti$_{0.6}$Al$_{0.4}$)N | 8.0 | 3m (チッピング剥離発生) |
| | 7 | 40 | $3.0\times10^{-3}$ | 〃 | 8.1 | 2m 〃 |
| | 8 | 40 | $2.0\times10^{-3}$ | 〃 | 4.2 | 4m 〃 |
| | 9 | 70 | $3.0\times10^{-3}$ | 〃 | 5.2 | 8m (正常摩耗 0.2mm) |
| | 10 | 70 | $2.5\times10^{-3}$ | 〃 | 9.0 | 10m 〃 |

[0013] When it was obtained and milling cutter cutting of the end mill was carried out in the following conditions, possible cutting distance until average width of flank wear land is set to 0.20mm was written together to Table 1. In a very normal wear form, super-life-ization is attained in end-mill cutting by making a field (111) carry out orientation of the coat so that more clearly

than Table 1.

[0014] It coated so that it might become the coat structure shown in Table 2 using the experiment equipment used in the example 2 example 1. The thickness of the compound nitride layer of Ti and aluminum was unified into 3 micrometers. The same cutting evaluation as an example 1 was performed, and the tool life was evaluated. The result is written together to Table 2. aluminum 2O3 formed membranes by plasma CVD.

[0015]

[Table 2]

| 試料番号 | | 中間層 (μm) | TiAl層 | 最外層 | I(200)／I(111) | 切削長(m) |
|---|---|---|---|---|---|---|
| 本発明例 | 11 | TiN (0.4μm) | (Ti0.6Al0.4)N (2.6μm) | - | 1.5 | 30m (正常摩耗 0.2mm) |
| | 12 | TiN (3.0μm) | (Ti0.6Al0.4)N (2.3μm) | TiCN (0.3μm) | 1.2 | 32m ( 〃 ) |
| | 13 | TiN (1.5μm) | (Ti0.6Al0.4)N (2.55μm) | TiCN (0.3μm) | 0.5 | 38m ( 〃 ) |
| | 14 | TiN (0.8μm) | (Ti0.6Al0.4)N (2.4μm) | (TiAl)NO (0.3μm) | 0.5 | 35m ( 〃 ) |
| | 15 | TiCN (0.3μm) | (Ti0.6Al0.4)N (2.4μm) | $Al_2O_3$ (0.3μm) | 2.0 | 39m ( 〃 ) |
| 比較例 | 16 | TiN (1.0μm) | (Ti0.6Al0.4)N (2.0μm) | - | 3.0 | 12m ( 〃 ) |
| | 17 | TiN (1.5μm) | (Ti0.6Al0.4)N (2.3μm) | TiCN (0.3μm) | 5.8 | 8m (チッピング) |
| | 18 | TiN (0.4μm) | (Ti0.6Al0.4)N (2.3μm) | TiCN (0.3μm) | 4.6 | 14m (正常摩耗 0.2mm) |
| | 19 | TiN (0.8μm) | (Ti0.6Al0.4)N (2.4μm) | (TiAl)NO (0.3μm) | 8.2 | 10m ( 〃 ) |
| | 20 | TiN (0.3μm) | (Ti0.6Al0.4)N (2.4μm) | $Al_2O_3$ (0.3μm) | 12.3 | 10m ( 〃 ) |

[0016] From Table 2, raising a tool life further is admitted by preparing an interlayer or an outermost layer of drum in this invention alloy which has 2.5 or more I(200)/I (111) values. In addition, TiN of the interlayer in Table 2 set I (111) to I (200)/1.0.

[0017] N (TiAlX) coat of the various composition shown in Table 3 using the experiment equipment used in the example 3 example 1 was created. 750 degrees C of coated test pieces were held for 30 minutes all over the air furnace, and the thickness of the formed oxidizing zone was measured. The result is also written together to Table 3.

[0018]

[Table 3]

| | 試料番号 | 皮膜組成 | 酸化膜厚(μm) |
|---|---|---|---|
| 本発明例 | 23 | $(Ti_{0.41}Al_{0.6}Y_{0.03})N$ | 0.7 |
| | 24 | $(Ti_{0.41}Al_{0.6}Cr_{0.03})N$ | 0.9 |
| | 25 | $(Ti_{0.41}Al_{0.6}Zr_{0.03})N$ | 0.7 |
| | 26 | $(Ti_{0.21}Al_{0.6}Y_{0.23})N$ | 0.1 |
| | 27 | $(Ti_{0.21}Al_{0.6}Zr_{0.23})N$ | 0.5 |
| | 28 | $(Ti_{0.4}Al_{0.5}W_{0.1})N$ | 0.8 |
| | 29 | $(Ti_{0.4}Al_{0.5}Si_{0.1})N$ | 0.1 |
| | 30 | $(Ti_{0.41}Al_{0.6}Si_{0.03})N$ | 0.2 |
| | 31 | $(Ti_{0.4}Al_{0.5}Hf_{0.1})N$ | 0.9 |
| | 32 | $(Ti_{0.3}Al_{0.5}Y_{0.1}Si_{0.1})N$ | 0.05 |
| 比較例 | 33 | $(Ti_{0.4}Al_{0.6})N$ | 1.8 |
| | 34 | $(Ti_{0.4}Al_{0.5}Nb_{0.1})N$ | 2.5 |
| | 35 | $(Ti_{0.4}Al_{0.5}Ta_{0.1})N$ | 3.3 |

[0019] An oxidation-resistant improvement of a coat is possible by addition of Y, Si, W, Cr, Zr, and Hf so that clearly from Table 3.

[0020]

[Effect of the Invention] By applying this invention, in cutting of the high degree-of-hardness steel exceeding Rockwell hardness 50 (C scale weighting), the adhesion of a coat and abrasion resistance are improvable, especially, generating of exfoliation of a coat during cutting is lessened and not the tool life by exfoliation but the tool life which employed efficiently the abrasion resistance which the membraneous quality itself has came to be acquired.

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[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] The surface coating end mill with which the value of I (200)/I (111) is characterized by the bird clapper 2.0 or less in the end mill which covered the compound nitride of Ti and aluminum, a charcoal nitride, and carbide when I (111) and diffraction intensity of a field (200) are set to I (200) for the diffraction intensity of the field in the X diffraction (111) of an enveloping layer.
[Claim 2] The surface coating end mill characterized by using as an interlayer the nitride of Ti which has 0.05-micrometer or more thickness 5.0 micrometers or less between a base, the compound nitride of Ti and aluminum, a charcoal nitride, and a carbide enveloping layer, and a charcoal nitride in a surface coating end mill according to claim 1.
[Claim 3] surface coating end-mill **** a claim 1 and given in two -- the surface coating end mill characterized by covering one sort of monolayers, or two or more sorts of double layers further on the compound nitride of Ti and aluminum, a charcoal nitride, and a carbide layer among the charcoal nitride of Ti, a carbonic acid nitride, the compound nitric oxide of Ti and aluminum, a carbonic acid nitride, a carbonation object, an oxide, and the oxide of aluminum
[Claim 4] The surface coating end mill characterized by transposing a part of Ti to one sort or two sorts or more in Zr, Hf, Y, Si, W, and Cr in the range below 60 atom % more than 0.05 atom % to Ti in a surface coating end mill according to claim 1 to 3.
[Claim 5] The surface coating end mill characterized by setting field granularity by the side of the rake face of an end mill to 1 micrometer or less in a surface coating end mill according to claim 1 to 4.

[Translation done.]